Space Weather Technical Forecast

Issued on Tuesday, 26 March 2024 at 12:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Further Minor/Moderate radio blackouts (R1/R2) expected. A reducing chance of Minor geomagnetic storms (G1) as CME influence eases. Electron Fluence likely rising above the Active threshold into the period.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES16 and 18 was moderate with AR3615 producing three further M1 flares in the past 12 hours. Eight active regions currently on the visible disc. AR3615 remains by far the largest and most complex group (Fkc/Beta-Gamma-Delta), with some spot consolidation evident in recent imagery. Changes in other groups were minor.

No significant Earth-directed Coronal Mass Ejections (CMEs) observed on available coronagraph imagery over the last 24hr.

Solar Wind / Geomagnetic Activity: The solar wind at L1 measured by ACE and DSCOVR were initially at strong-very strong speeds (around 800 km/s) following the arrival of the CME associated with the X1.1 flare on the 23rd March that arrived at L1 at 24/1410UTC. From around 25/1500UTC winds began erratically declining to reach current strong speeds of around 630km/s. The solar wind density has been at average levels, with a mostly reducing trend, although showed a small rise after 26/0930 UTC. The IMF was at weak levels, less than 8nT. Bz was weak and mostly positive with a few short periods of negative, +6nT to -4nT. The phi angle largely negative (towards the Sun) initially but turned positive (away from the sun) around 25/1500UTC. The net result of the above solar wind measures was initially Active (Kp4-5) geomagnetic conditions, which soon reduced to Quite to Unsettled (Kp 1 to 3).

Energetic Particles / Solar Radiation: Solar radiation was at S1 levels initially but on a slow and steady decline, falling below the S1 threshold from 25/1410UTC.
High energy electron flux (greater than 2MeV) observed at GOES16 was at Normal Background levels. The observed 24-hour fluence was below the Active threshold, with a value at 26/0001UTC of 1.06e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Generally moderate solar activity is expected, with further M-class flares expected from primarily the highly active AR3615 through the forecast period, with a slight chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: A CME associated with the X1.1 flare from a broad region north of AR3614 on the 23rd March, produced a complex halo CME which arrived at L1 at 24/1410UTC. There are no other Earth-directed CME's currently in the forecast.
Solar winds at current strong levels expected to decline erratically through day 1 (26 Mar) and into day 2 (27 Mar) as the impacts from the CME continue to wane. With any residual enhancement associated with CH12/- expected to be clearing. Winds are expected to continue

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to fall towards background values into day 3 and 4 (28-29 Mar) in the absence of forecast enhancements.

Generally Unsettled to Active conditions expected initially but with a steadily reducing chance of further G1/Minor storm conditions. By days 3 and 4 (28-29 Mar) conditions expected to become generally Quiet (Kp1-2) in the absence of any further CME enhancements.

Energetic Particles / Solar Radiation: High energy proton flux, as observed by GOES18 is continuing to decline from recent enhancement. A continued slow decline is expected in the absence of further significant flare activity.

High energy electron flux (greater than 2MeV) remains at background levels at first, given the ongoing HSS and recent CME influences. Activity is expected to increase given the solar winds likely ease in coming days with a sharp increase likely to high levels. The associated 24-hour fluence is below Active threshold initially, but with an increasing likelihood of reaching Active fluence through the guidance period, becoming expected by days 3 and 4 (28-29 Mar).

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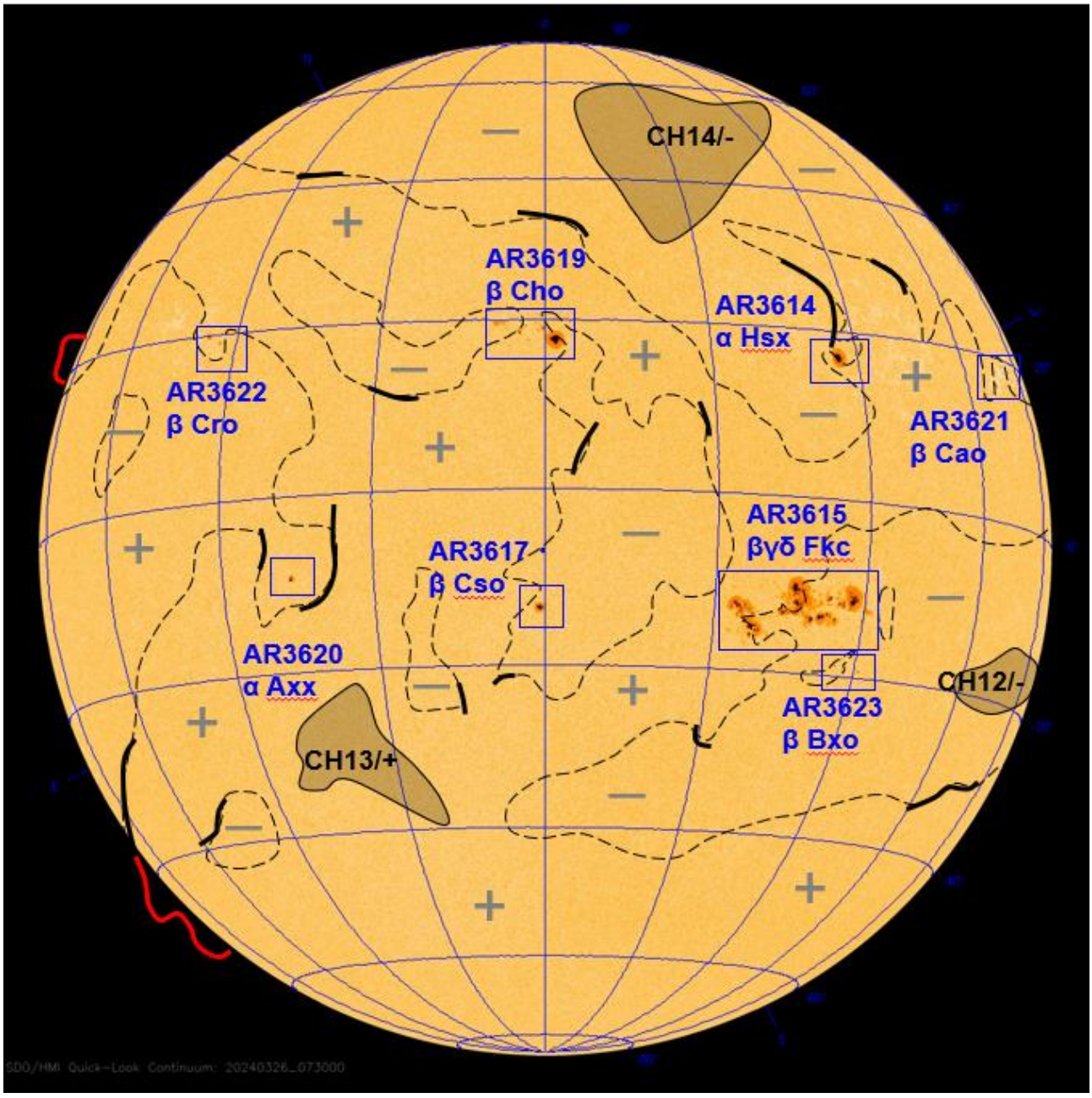
Figure 1. Solar Analysis Valid 26/0800 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME associated with the X1.1 flare from a broad region north of AR3614 on the 23rd March, produced a complex halo CME which arrived at L1 at 24/1410UTC. There are no other Earth-directed CME's currently in the forecast.

Solar winds have reduced slowly but erratically, and are currently at strong levels. A continued slow and erratic decline is expected through day 1 (26 Mar) and into day 2 (27 Mar) as the impacts from the CME continue to wane. With any residual enhancement associated with CH12/- expected to be clearing by that stage winds are expected to continue to fall towards background values into day 3 and 4 (28-29 Mar) in the absence of forecast enhancements.

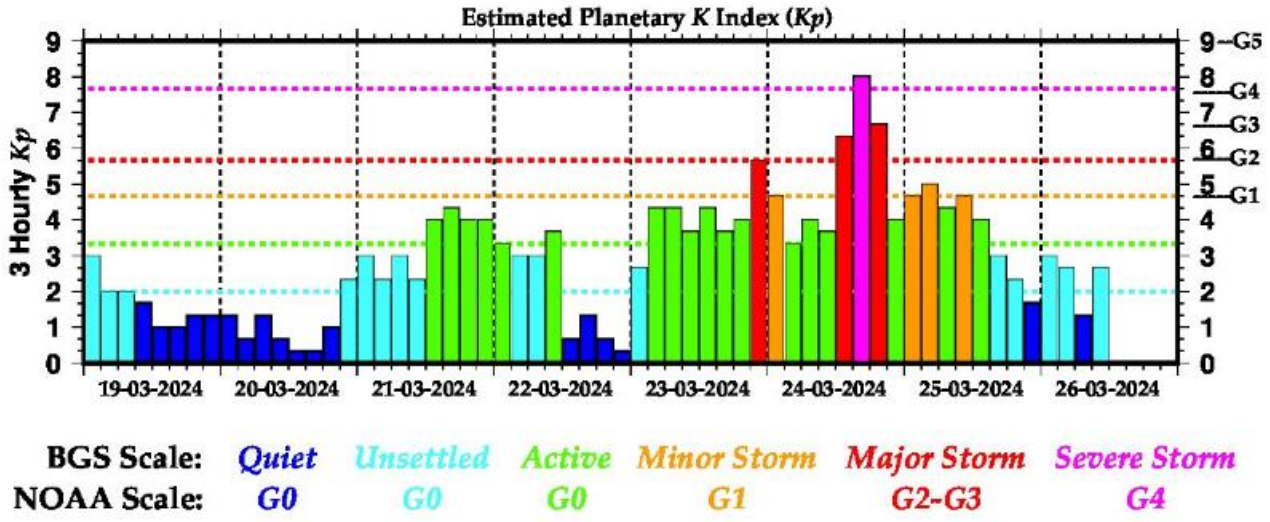
Generally Unsettled to Active conditions expected initially, with a steadily reducing chance of G1/Minor storm conditions. By day 3 and 4 (28-29 Mar) conditions are expected to become generally Quiet (Kp1-2) in the absence of any further CME enhancements.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	30	5	1
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

None expected.

Figure 2: BGS plot of planetary K indices for the past 7 days.



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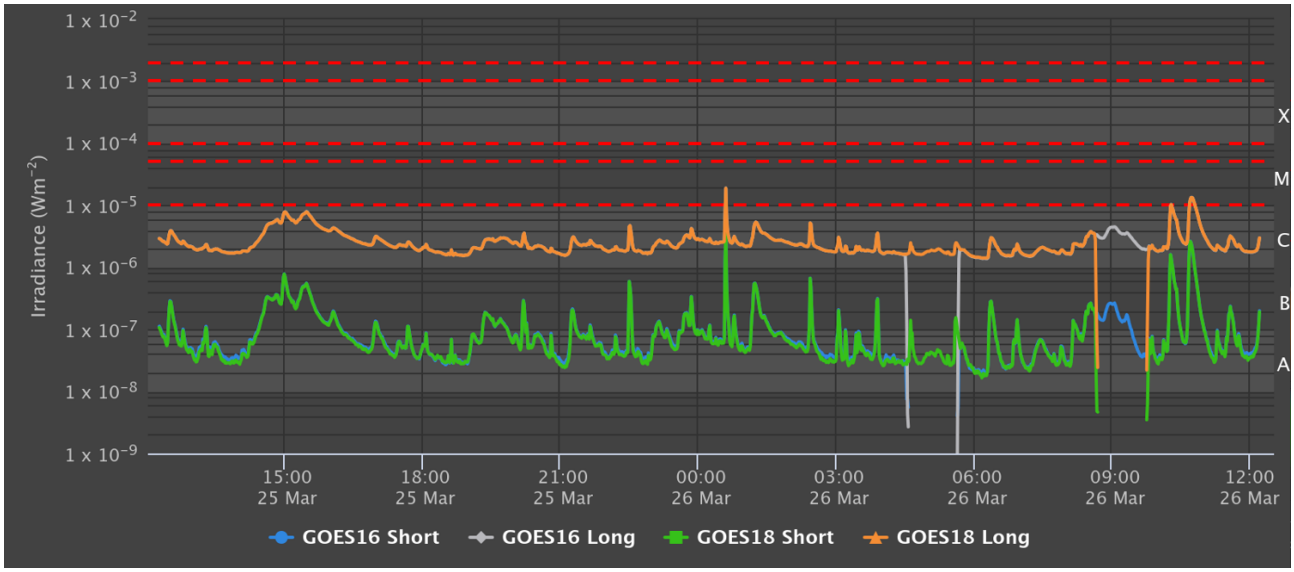
Radio Blackouts - X-Ray Flares:
The current Earth-facing disc remains dominated by AR3615 (Fkc/Beta-Gamma-Delta), by far the largest and most complex group. This region has been highly active in recent days and has produced three further M1 flares in the past 12 hours. The X1.1 flare on the 23rd was primarily associated with AR3614, which remains generally stable and much more magnetically simple, though it remains within a large plage region. All other regions remain significantly simpler, although recent flare and CME activity from AR3622 in the northeast indicate they should not be completely discounted.

AR3615 (and AR3614) will remain on the visible disc throughout this guidance period, and will continue to represent a high risk of activity, with further M-class flares expected and slight chance of isolated X-class flares. Some suggestions from far-side sounding data that returning regions may rotate onto the southeast disc into the later half of the period. For now flare risk is maintained throughout.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	80	80
Very Active	R3 to R5 X Class	No	20	20	20	20

Figure 3: GOES16 and 18 X-ray flux



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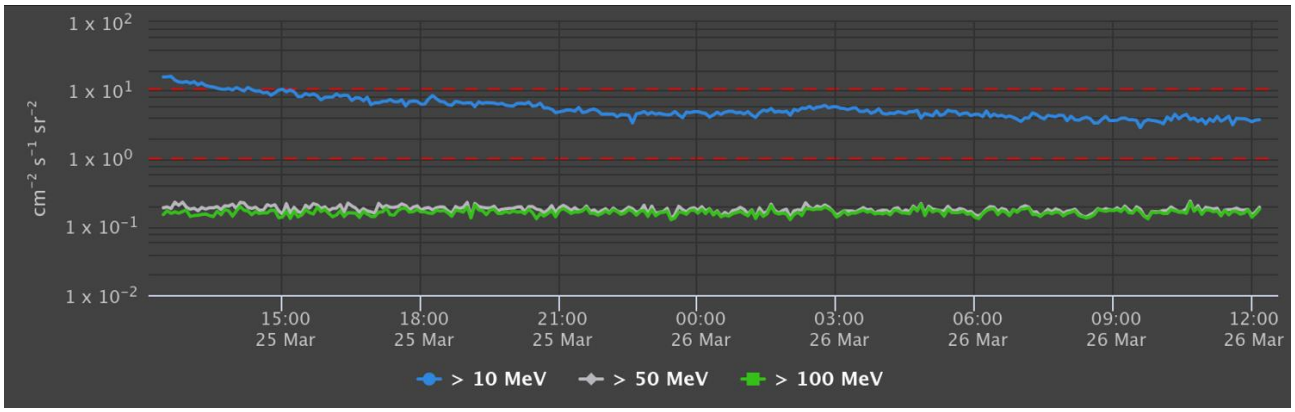
Solar Radiation Storms - (High Energy Protons):
High energy proton flux, as observed by GOES18 is continuing to decline from recent enhancement. A continued slow decline is expected in the absence of further significant flare activity, with the chance of any further enhancement dominated by AR3615 as it makes continued progress westward.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	40	30	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES18 proton flux.



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High Energy Electrons Event (≥ 2MeV):
GOES16 high energy electron flux is at background levels currently given the likely ongoing connection to the HSS of CH12/- and recent strong CME passage. As geomagnetic activity and solar wind speeds likely ease over the next few days the electron flux at GEO is expected to quickly rise to Moderate or High levels.

The associated 24-hour fluence is currently below the Active threshold. Fluence is expected to rise sharply in the coming days with active fluence becoming increasingly likely. MOSWOC REFM output shows very high levels of forecast fluence day 1 (26 Mar), this is viewed as unlikely given likely ongoing fast solar winds. However, an increase in Fluence above the active threshold into days 3 and 4 (28-29 Mar) is accepted as good guidance.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^{8}$	No	10	50	80	80
Very Active	≥ 2 MeV ≥ $1x10^{9}$	No	5	5	15	10

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